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Lectures Series 222

Computer Assisted Exercises
Background

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Notes for Slide 1

Summary

This presentation contains general background information describing computer assisted exercises. It provides a basic definition, list key characteristics and applications of computer assisted exercise systems and discusses why CAX systems are increasingly useful for defense applications.

CAX systems comprise several advanced information technology areas: Human Computer Interface Technologies, Command and Control Systems and their Integration, Simulation Systems, and Exercise Support Tools. This presentation reviews how each area contributes to CAX systems, and highlights issues involved in further development.

Topics

- Current Environment
- Definition of Computer Assisted Exercise (CAX)
- Main Characteristics
- Military Implications
- Examples
- Key Enablers
- Main CAX Systems and Agencies
- Preview of Next Lectures

Notes for Slide 2

The objective of this presentation is to provide background information on Computer Assisted Exercises, why they are important today, and the technologies that underpin their development and use.

CAX systems have been used in major applications for nearly 20 years. Though initially used for Cold War oriented scenarios, CAX systems are inherently flexible, and so they have continuing applications to current international security challenges and needs.

To make the discussions concrete, 2 examples of current CAX systems will be discussed; the Joint Theater Level Simulation, used by NC3A and several countries, and the Joint SAF system, used by the US Joint Forces command.

Notes for Slide 2 (Continued)

Advanced information technologies such as Human Computer Interfaces and Simulation Systems form the basis of all CAX systems. This paper will review the main technology areas and indicate where advances are needed.

As a guide for further fact finding, sources are provided for organizations currently developing or applying CAX systems.

Several presentations will follow this one. These will discuss the operational requirements for CAX, several technical topics, and finally a view of areas of future needs.

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Current Environment

- Nations facing new tasks, with reduced forces and budgets
  - Regional contingency operations, crisis management, peace keeping, etc.
- Large scale field and command post exercises less feasible
- Continuing military requirements to train and exercise staffs, and to address new command and control needs and issues
- Information technologies enable the development of new and increasingly more capable training and exercise systems ➔ Computer Assisted Exercises

Notes for Slide 3

The current global security environment presents nations will dual challenges. Since the end of the Cold War, many nations have decreased the size and budgets of their defense forces. These last 12 years have also witnessed a growing set of new missions, including humanitarian assistance, peacekeeping, crisis management, and small scale contingencies, for example. Some nations also have used military forces to combat drug trafficking and terrorist activities.

In the past, a traditional method for training and preparing forces has been through the use of large-scale field and command post exercises. Today these have several disadvantages due to the cost and manpower involved. In the case of field exercises, environmental concerns in the host nation also limits what can be undertaken. Apart from these concerns, these exercises require significant time to plan and set-up and are inherently not very flexible, again due to the large numbers of participants.

Notes for Slide 3 (Continued)

To help defense forces prepare for new missions and new coalitions among nations, exercises are more important now than in the past. Nations need to determine new command and control approaches, train for new operational environments, and consider how emerging capabilities can be used to enable new operational concepts.

Using advanced information technologies such as simulation, human computer interfaces, networks, and techniques that link real command and control equipment to a simulated environment, one can create a flexible training and exercise capability. These computer assisted exercises allow more frequent exercises, at less cost compared with field exercises, and are well suited to the needs of today's defense forces.

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A Definition

Computer Assisted Exercise

An exercise using computer models designed to place the command and control element of a headquarters in a realistic, stressful combat-like environment to stimulate decision-making, command and control staff interaction and coordination

Notes for Slide 4

Though this is a somewhat generic definition, it highlights the key elements that comprise a computer assisted exercise.

First is the creation of a simulated environment that can stimulate human decision-making. Computer are used to simulate forces and their interactions and also for presenting relevant information to the participants. Typically, this is the command and control information that flows to and from commanders and their staffs.

Second, the computer assistance appears in several ways. The computerized combat simulations are used in the exercise preparation phase to construct and fine-tune the basic scenario. During the exercise, computers are used to simulate those elements in the exercise that are not played by people or real equipment. The exercise controllers to monitor the events and initiate corrective actions. Once the exercise ends, computers aid the analyses.

Notes for Slide 4 (Continued)

Third, computers are used to create linkage, or a translation, between the information and databases that make up the simulated environment, and the information and databases used by real command and control systems.

Applications of CAX include both education and training. For training, the typical audience may be smaller staff groups with a focus on specific areas or functions. For exercises, there is typically a broader scope of participants and the focus in on the functionality of a major organizational structure. A key interest in the latter case is to activate the command and control structure for crisis or wartime scenarios.

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Characteristics of CAX

- **Purpose:** train decision makers and staffs, staff elements and/or individual staff members in a wide range of military operations; or assist the development of operational plans, procedures, and doctrine

- **Foundation:** use of simulation models which generate battlefield situations and/or represent a (synthetic) operational environment

- **Key feature:** dynamic play provided by live actors representing opposing forces, or by live exercise control staff

Notes for Slide 5

The participants in a CAX range from individual decision makers and/or staff members; small staff groups; or a full staff. Also, a CAX can comprise participants from a single service, a joint and/or combined staff, and mixes of military and non-military staffs.

The use of CAX potentially span a wide range of settings and force compositions. For example:

- The level of command can range from tactical, to operational, to strategic
- The situation, or scenario, can be one of non-conflict, crisis management, through low- , medium-, and high-intensity conflict
- The geographical locations can be local, theater-sized, global, or even an entirely synthetic region and topography

Notes for Slide 5 (Continued)

The technical foundation of CAX is the use of simulation to enable the training or education audience to become immersed in a decision-making environment. The main components of a CAX are thus the simulations of the battlefield forces, actual or representative command and control equipment, the friendly force training audience, an exercise control staff, and the threat forces. The last component can be played by the exercise control staff. The simulations populate the environment with force elements, adjudicate their interactions, and provide information to the command and control systems.

The distinguishing feature of CAX is the interaction among live players on the friendly and threat side. The dynamic nature of the action during the exercise creates a sense of immersion and a possibly more authentic experience.

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Military Implications of Further Development, Use of CAX

- Enable more frequent, flexible exercise programs and thus improve military readiness

- Save resources by substituting simulation-based exercises for some live field exercises

- Facilitate analysis of future military organizations and systems, especially for issues dealing with command and control and with joint and combined operations

Notes for Slide 6

As CAX systems become more capable, they will provide an important means for nations to meet their defense needs evolving from increasing breadth of missions and international security coalition agreements.

The inherent flexibility of being able to simulate any geographic region, any scenario, and any arrangement of forces, enables computer assisted exercises to be planned, developed, and modified more quickly as compared with live field exercises. As exercise schedules make greater use of this capability, one can expect an effect on military readiness.

Notes for Slide 6 (Continued)

Much of the cost of live field exercises is related to the large number of soldiers and equipment that must be transported to the exercise location. With CAX, the simulations play the role of many of the forces, both people and equipment. Also, in the case of command post exercises, one avoids the costs of mitigating, or repairing any damage to, the local environment. It is generally accepted that live field exercises will still be needed, though the balance among the various forms of exercises needs continuing assessment.

The greatest potential benefit regarding the use of CAX is to allow defense forces to experiment with how to meet future requirements. These experiments will address issues of new command and control organizations, new operational concepts, and new systems. Such experiments require an iterative approach. CAX systems are well suited to this purpose.

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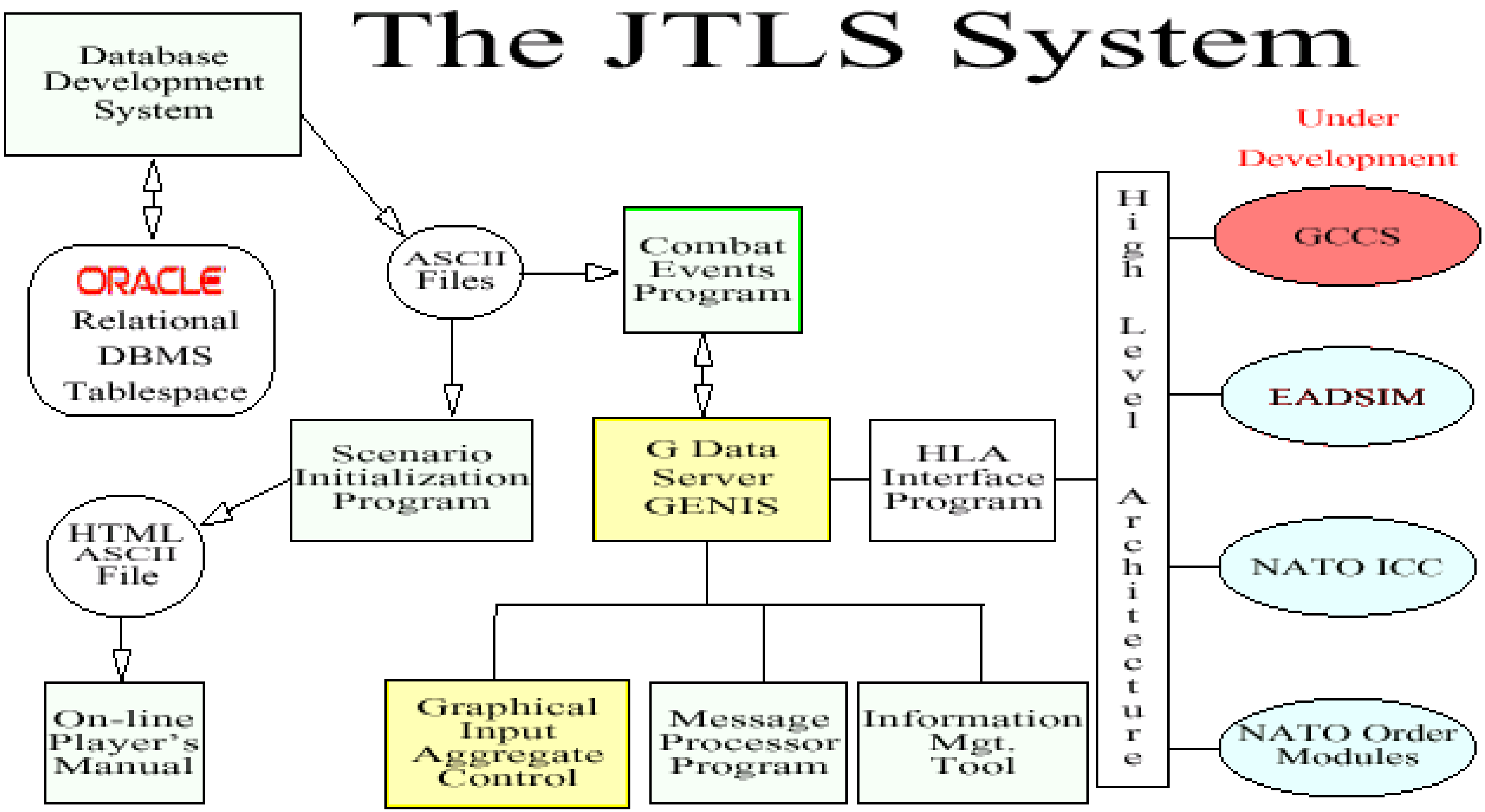
Example - Joint Theater Level Simulation



Notes for Slide 7

The Joint Theater Level Simulation (JTLS) system is an interactive, multi-sided wargaming system that models a joint and coalition force warfare environment. JTLS models air, ground, and naval combat, with logistical, Special Operation Force (SOF), and intelligence support. It was designed as a tool for use in the development and analysis of joint and coalition operation plans, but is frequently used as a training support model. It is theater-independent. The accompanying graphic shows a federation of the JTLS simulation with 4 other simulations, using the High Level Architecture.

JTLS started development in 1983 as a project funded by the U.S. Readiness Command, U.S. Army Concepts Analysis Agency, and the U.S. Army War College. Program Management of JTLS is provided by the United States Joint Forces Command, Joint Warfighting Center, Suffolk, VA.

Notes for Slide 7 (Continued)

The JTLS system consists of six major programs and numerous smaller support programs that work together to prepare the scenario, run the game, and analyze the results. The JTLS system operates on a single computer or on multiple computers, either at a single or at multiple distributed sites.

Model features include Lanchester attrition algorithms, detailed logistic modeling, and explicit air, ground, and naval force movement. In addition to the model itself, the JTLS system includes software designed to aid in scenario database preparation and verification; entering game orders; and obtaining scenario situational information from graphical map displays, messages, and status boards. JTLS is operated by the United States, NATO C3A, Japan, Korea, Turkey, Thailand, Australia, UK, France, Greece, and the United Arab Emirates.

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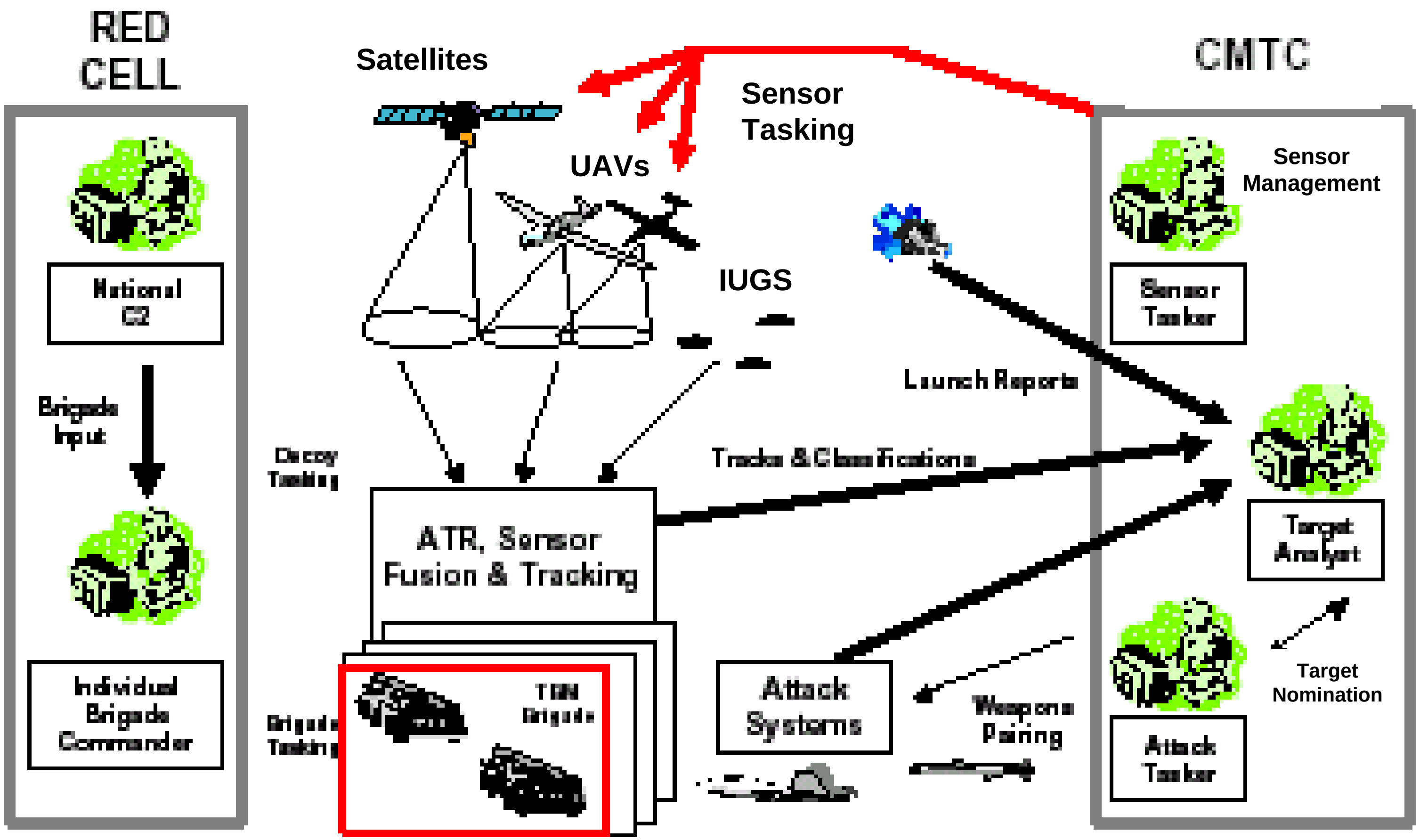
JointSAF



RED CELL
National C2
Brigade Input
Individual Brigade Commander
Satellites
UAVs
Sensor Tasking
IUGS
Decoy Tasking
ATR, Sensor Fusion & Tracking
Brigade Tasking
TBM Brigade
Launch Reports
Tracks & Classifications
Attack Systems
Weapons Pairing
CMTC
Sensor Management
Sensor Tasker
Target Analyst
Target Nomination
Attack Tasker

Notes for Slide 8

The JSAF is a high- fidelity synthetic battlespace for joint training. It has a number of characteristics that make it particularly useful for experimentation. For example:

- JSAF permits humans to interact directly with the synthetic battlespace.
- JSAF is High-Level Architecture (HLA) compliant, so it can federate with other virtual or constructive HLA simulations and some simulations that are not HLA.
- JSAF is hosted on a series of networked personal computers (PCs).
- JSAF maintains a series of internal communications systems (voice and e-mail), particularly valuable for HITL experiments.
- JSAF has an AARS (after action review system) that provides a range of data and playback capabilities. The AARS provides a Killer/Victim scoreboard and a measure of effectiveness/measure of performance (MOE/MOP) table at the end of each day during the trial. St the conclusion of each trial, the performance history of each of the most important Red entities, e.g., TELs, MTTS, etc. is provided by the AARS.

Notes for Slide 8 (Continued)

In a recent experiment the Blue Cell used “future” C4ISR to track targets, pair weapons with targets, direct the weapons attack, and maneuver UAVs carrying the sensors. The Red Cell interfaced with the Red forces through the standard JSAF interface devices. As a result of this HITL capability, Red and Blue engaged in real-time, dynamic free-play. Further, JSAF permitted the Blue Cell to reconfigure its C2 environment to better execute its mission. These aspects of JSAF were critical to experimenting with human C2 in a Red-vs.-Blue, free play, entity-level synthetic battlespace.

JSAF simulates warfare at the platform level. JSAF simulates the entire range of Red and Blue forces, as well as a wide range of synthetic environments (including various types of terrain). JSAF collects all of the data required for the post-experiment analysis.

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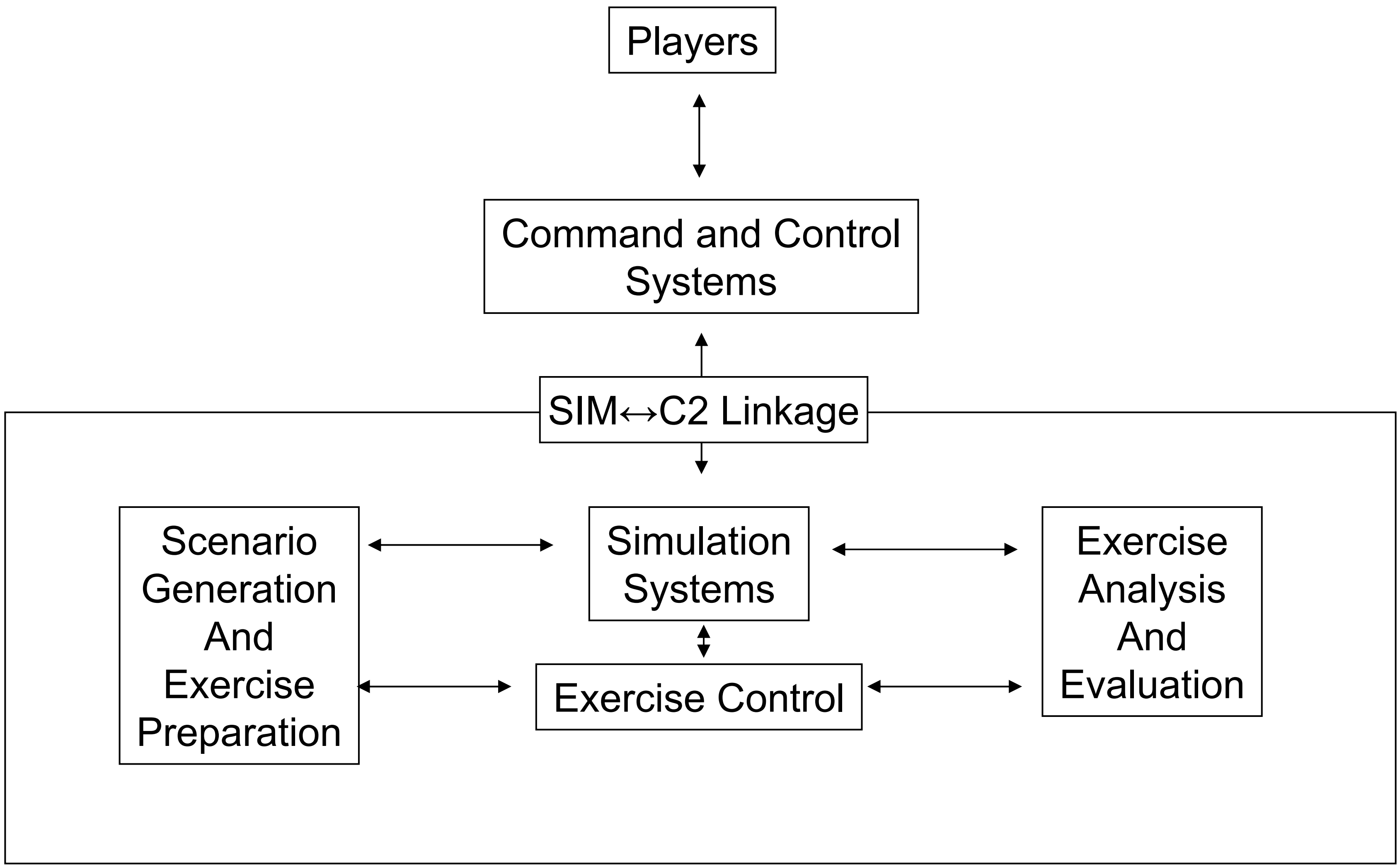
CAX Functional Architecture



Notes for Slide 9

This diagram illustrates the principal functional components of a CAX system.

In the lower box are the components of the simulation portion of a CAX system. The Simulation Systems may comprise 1 or more simulations. Often, multiple independent simulations are federated to create a unified simulation of the battlespace. These simulations create the overall synthetic environment representation. The simulations themselves may be linked over a network.

A CAX system also contains a variety of tools to aid in the preparation of an exercise. Examples include tools to create and fine-tune a scenario (the time-phased movement of forces and events), tools that assemble and validate the databases, tools that verify the proper configurations of the computers and simulations themselves, and tools that produce documents about the scenario and exercise set-up.

Notes for Slide 9 (Continued)

To aid both the monitoring of the events of the exercise and to measure the results, analysis tools gather statistics and are used to conduct after action reviews.

The Simulation to C2 Linkage provided a real-time interface between the players and their real world command and control system and the synthetic environment. This module may also contain computerized representation of the opposing forces.

There are 2 areas involving human participants: the training or exercise players themselves, and the exercise control personnel. The exercise players comprise the primary audience and possibly others needed to ensure adequate representation of key roles. The exercise control works to ensure the free play of events maintains a course that serves the overall objectives.

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Key Enablers

- Human Computer Interface Technologies
- Command and Control Systems and their Integrations
- Simulation Systems
  - Especially distributed simulation and interoperability protocols
- Exercise Support Tools
  - Especially for exercise preparation, run time control, and analysis

Notes for Slide 10

There are 4 technology area that are of primary interest to Computer Assisted Exercises.

Human Computer Interface technologies contribute to the many ways that humans interface with the computer and command and control systems. These involve all phases of an exercise, starting from exercise preparation, through the conduct of the event, and during the post-exercise analysis and review.

Command and Control systems and their Integrations refers to the information systems used to manage real world battlefield activities, on the one hand, and the means to link these to a synthetic (simulated) environment.

Notes for Slide 10 (Continued)

The Simulation Systems technologies refers to systems that dynamically represent battlefield entities and processes. Key areas of research include the means to federate simulations to create a more complex synthetic environment, and improvements in the simulated representation of certain aspects of the battlefield (e.g., higher echelon command and control)

The Exercise Support Tools are required to help the CAX staffs in the preparation, conduct, control, and analysis phases.

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Human Computer Interface Technologies

- **Input/Output Technologies**
  - E.g., standard modes, automated voice/speech, head/body trackers, gestures, interfaces that learn individual’s preferences

- **Display Technologies**
  - E.g., large easily transportable displays, electronic paper, virtual reality immersion, context sensitive presentations

- **Integrated Interfaces**
  - E.g., intelligent rooms that facilitate multi-modal interaction with the participants

Notes for Slide 11

For typical CAX systems, the input and output information addresses information on the physical and natural environment of the scenario region; mobility, logistics, and line-of-sight calculations for the terrain, data on system and force capabilities. During and after the exercise the participants work with sensor and command and control reports, displays of the progress of the scenario, and statistics on the performance of each side. To help keep exercise costs as low as possible, and to ensure the players can effectively work with the needed information in a timely manner, new input and output technologies such as voice recognition and speech synthesis are important. At a more advanced level, interface mechanisms that remember the preferences and styles of individual users may bring important time and cost savings.

Notes for Slide 11 (Continued)

A key objective for the display technologies is to allow the participants to gain a consistent and up-to-date view of events during an exercise. Large, readily transported displays help keep exercise costs down, and can serve to give the players a common view. A new development, electronic paper, may be useful where the exercise players must command forces while being mobile. There are software display applications that make the information presentations context-sensitive. These can aid the rapid examination of complex information.

Integrated Interfaces refers to technologies that involve several modalities of human-computer interactions. Examples include: voice, gesture, personalized presentation schemes, intelligent agents searching global databases, multi-media coordination of speech, text and graphics presentations, automated layout of information spaces, and software that assists the user to focus on the relevant information.

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Command and Control Systems and their Integrations

- Integrate C2 Information Systems (CCIS) with the exercise staff
- Integrate CCIS with the exercise environment
- Integrate CCIS with exercise support elements

Notes for Slide 12

The exercise staff comprises the commanders and organizations that are the object of the exercise. The exercise system must support interactions among the human players (requiring one type of integrating mechanism) and interactions of among the live players and players that are automated (i.e., computerized). This involves 2 broad technology areas: the ability of computers to understand the communications and intent of humans performing command and control activities, and the ability of computers to represent the command and control behaviors of commanders and their staff.

Some issues regarding the integration of the CCIS with the exercise environment include the following. The CCIS operate in real time, whereas simulation exercises sometimes proceed in an event driven manner in which time does not proceed uniformly. This makes synchronization of the simulated environment and the human players interactions a key technical objective. The simulated environment must replicate that part of the CCIS communications not explicitly included with the real systems. Simulation of realistic communications infrastructures is still difficult. A third issue is the ability of the CCIS to include information from the real world in its interactions with the simulated system. Examples of real world information of interest include weather, key events, sensor reports, and events that cause degradations or disruptions in the CCIS.

Notes for Slide 12 (Continued)

The CCIS include useful data for the simulation system. A means must exist to allow these data to be exchanged. Examples include unit status data, orders of battle, target data, descriptions of information flows, and system performance data. A goal is to make interoperable the databases that underpin the CCIS and the simulation systems. To support the exercise control staff, the CCIS must enable the inspection of its databases on forces, events, and the sequence of player decision making. Using this information, the exercise control staff can redirect the course of exercise to keep it focused on the overall objectives. This requires the ability to inject events into the CCIS.

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Simulation Systems

- Three types: constructive, virtual, live
- Simulation networks and protocols
- Modeling
- Development and Maintenance

Notes for Slide 13

Simulations can be classified according to 3 general types. Constructive simulations operate with no human participation after the initialization phase. Typically, constructive simulations are used to examine many what-if cases surrounding 1 or more base cases. Virtual simulations use virtual reality to create an immersive environment for the players. This immersive environment can be a tank simulator, for example, or a command post. Live simulations represent real equipment operating in an instrumented real world environment. The instrumented activities can be integrated with the other types of simulations.

Protocols and standards to network simulations exist for a wide range of simulations. These include simulations at the entity level of resolution and at the aggregate level (i.e., where force units such as companies or battalions are the basic elements), and simulations that are time-stepped and event-stepped. There are also on-going efforts to define overarching architectural concepts to facilitate the networking, or federating, of simulation systems. Network issues such as network management and network security also affect the use of CAX.

Notes for Slide 13 (Continued)

In addition to modeling the weapon system characteristics and interactions, the modeling of humans on the battlefield, both in the role of dismounts and in command staffs, is a current area of research. As non-combat missions are further considered, the modeling of civilians and political institutions will become important to CAX. Technologies that support rapid knowledge acquisition and rapid transfer of this knowledge of behaviors into a computer simulation are important.

The time and cost to develop and maintain simulations can be improved upon through greater use of common databases of the physical and natural environment, of system characteristics, and tools that validate and verify the correctness of a simulation. Increasingly, open standards for the construction of simulation systems are becoming available.

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Exercise Support Tools

- Exercise Support Tasks
  – Prepare input data on terrain, forces, scenario
  – Design exercise and determine evaluation criteria
  – Prepare exercise documentation, conduct training & rehearsal
  – Execute simulation, including response and control cell activities
  – Conduct post-exercise analyses

- Technologies
  – Advanced database technologies
  – Display and input technologies
  – Artificial Intelligence
  – Expert systems

Notes for Slide 14

The exercise support tasks span the use of CAX over the project life of an exercise. The overall objective is to ensure the exercise objectives are met in a timely, cost effective manner.

Due to the complexity of designing an exercise, the reuse of common databases on forces, terrain, and scenarios is a useful approach, where possible. The design of an exercise may be aided by fast-running versions of the simulations. These allow initial testing of whether the exercise objectives will be met, and they afford an early opportunity to examine the sufficiency of the chosen evaluation criteria.

To help conduct rapid training and rehearsal, extensive documentation and on-line training aids are helpful. To the extent these can be created automatically via automated tutoring mechanisms or expert systems, this may be achievable at less cost.

Notes for Slide 14 (Continued)

During simulation execution, display and input technologies are used by all exercise personnel as they interact with the CAX system. As discussed earlier, the use of advanced technologies here will allow fewer personnel to be used. Good interface design and technologies are important to the participants' being able to even use the CAX system.

Exercises will produce significant quantities of data. Both for the purposes of the exercise controllers and for the post-exercise analyses, these data should be subject to quick examination. It is especially important, for example, to verify early that the exercise is proceeding according to its general design and not affected by subtle flaws that would invalidate the overall effort. Artificial intelligence, intelligent agents, and similar technologies that can automatically examine large datasets for patterns, anomalies, and correlations, are valuable.

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Main CAX Systems and Agencies

- **Systems**
  - Joint Training Confederation
  - Joint Theater Level Simulation
  - JointSAF
- **Agencies**
  - NC3A
  - Warrior Preparation Center
  - US Joint Forces command

Notes for Slide 15

As a guide to further investigations, a few current CAX systems and user organizations are listed here.

The Joint Training Confederation (JTC) is composed of a collection of service models that have been used to support joint training exercises since 1992. The 1999 version of the JTC consists of nine simulations and includes the major functionality for joint training exercises. These simulations support combat interactions between air, land, sea and space objects (including tactical ballistic and cruise missiles), provide a common electronic warfare environment, and provide a high resolution training environment for Army logisticians and intelligence cells.. JTC Simulations: CBS, AWSIM, RESA, MTWS, CSSTSS, JQUAD (consists of: JECEWSI, JCAS, JOISIM, and JNETS, TACSIM, MDST, AMP.

The Joint Theater Level Simulation, discussed previously, is used in major exercises by the US and other countries.

Notes for Slide 15 (Continued)

The JointSAF simulation is an entity level simulation in current use by the US Joint Forces Command for joint experimentation. It comprises high resolution environmental simulations (terrain, phenomenology), platform, sensors, command and control systems. It supports all combat interactions of land, sea, and space assets, and all types of weapon systems.

Among the major agencies developing or using CAX systems are NC3A in the Netherlands, the US Warrior Preparation Center in Germany, and the US Joint Forces Command in Virginia.

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Topics for Remainder of Lecture on CAX

- Military Operational Requirements
- CAX System Architectures and Services
- Automated Command and Control Information Systems
- Practical Examples and Future Needs

Notes for Slide 16

The next sessions for the topic of Computer Assisted Exercises will cover these themes.

First is a discussion of the military operational requirements for CAX. CAX systems are under continuing development, both for technological reasons and to address changing needs. Understanding the requirements from the military's perspective will inform on priorities for future work.

Second is a more in depth discussion of how CAX systems are organized in terms of their architecture. This will describe the key functions performed by a CAX system, the various services (e.g., network services), and the main technological underpinnings.

Third is a discussion of automated command and control systems. This will provide a foundation to better understand the requirements for linking simulation systems with real world command and control information systems.

The final topic presents some concrete examples of CAX systems, and highlights key needs for future consideration.

Computer Assisted Exercises - Background

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